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## Volunteered Geographic Information: The Nature and Motivation of Producers\*

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### Abstract

Advances in positioning, Web mapping, cellular communications and wiki technologies have surpassed the original visions of GSDI programs around the world. By tapping the distributed knowledge, personal time and energy of volunteer contributors, GI voluntarism is beginning to relocate and redistribute selected GI productive activities from mapping agencies to networks of non-state volunteer actors. Participants in the production process are both users and producers, or 'producers' to use a recent neologism. Indeed, GI voluntarism ultimately has the potential to redistribute the rights to define and judge the value of the produced geographic information and of the new production system in general. The concept and its implementation present a rich collection of both opportunities and risks now being considered by leaders of public and private mapping organizations world-wide. In this paper, the authors describe and classify both the types of people who volunteer geospatial information *and* the nature of their contributions. Combining empirical research dealing with the Open Source software and Wikipedia communities with input from selected national mapping agencies and private companies, the authors offer different taxonomies that can help researchers clarify what is at stake with respect to geospatial information contributors. They identify early lessons which may be drawn from this research, and suggest questions which may be posed by large mapping organizations when considering the potential opportunities and risks associated with encouraging and employing Volunteered Geographic Information in their programs.

**Keywords:** volunteered geographic information (VGI), volunteers, producers, spatial data infrastructure, crowdsourcing, urban sensing

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## 1. BACKGROUND

Advances in geospatial positioning, Web mapping, cellular communications and wiki-based collaboration technologies have now surpassed the original visions of the architects of spatial data infrastructures around the world [e.g., (Goodchild, 2007), (Craglia et al., 2008) and others]. Collaborative Web-based efforts like *Open Street Map*, *Tagzania*, *Wayfaring.com*, the *People's Map*, and *Platial: The People's Atlas*, now enable experts and amateur enthusiasts alike to create and share limited, theme oriented geospatial information.

Examples of ways in which citizen input is used to strengthen emergency response efforts are now found in the popular press and in refereed media [e.g., (Laituri and Kodrich, 2008) and (Crutcher and Zook, 2009)]. Further, McLaren and Enemark (2008) discuss the role of cellular telephones in generating a move to distributed citizen sensing and supporting "Mobile(M)-government" as an extension to e-government, providing information and services through mobile devices like cell phones, laptops, PDAs and even RFID tags working within a wireless communications infrastructure. Cuff et al. (2008) coin the term "urban sensing" to describe this.

Commercially, Google Map Maker now provides to citizens in 43 countries the ability to help populate and update Google Maps road centerline and attribute data in that country (See Figure 1) [(Jones, 2007); (Google, 2009)]. Firms like Tele Atlas, NAVTEQ and TomTom each already use Web-based customer input to locate and qualify mapping errors and/or feature updates required in their road network databases [(Biersdorfer, 2007); (Helft, 2007)].

**Figure 1: Countries in which Individuals Collect and Edit Their Own Data using Google Map Maker (Google, 2009)**



The concept of “user-generated content” (also called “user-created content” or “consumer-generated media”) is nothing new [(IAB, 2008), (OECD, 2007)]. Cook (2008) and others document a long history of both passive and active “User Contribution Systems (or UCS) in the consumer market. Further, there are numerous examples of public participation GI systems where interested individuals have offered input and feedback to professionals and communities of interest in both roundtable and Web-based settings (e.g., (Craig, 2002); (Tang et al., 2005); (Sieber, 2006)].

What is different with Web 2.0-based contribution initiatives is the more influential role assumed by the community. Axel Bruns (2006) outlines four fundamental characteristics of informational ‘produsage’ as distinct from informational production:

(1) *community based*: collaborative engagement of large communities of participants in a shared project, that exploits the ‘power of eyeballs’ and the ‘long tail’ of diverse knowledge, abilities and interests outside a narrow elite of knowledge workers;

(2) *fluid roles*: the necessity to allow for a fluid movement of individual ‘producers’ between different roles within the community;

(3) *unfinished artefacts*: the “palimpsestic” nature of volunteered or “produced” content -- resembling the repeatedly overwritten pages of ancient texts which hold the latest version and the history of examination, discussion and alteration of the artefact; and

(4) *common property – individual merit*: members of the produsage community adopting more permissive approaches to legal and moral rights in intellectual property than those found in traditional content production.

Bruns’ research into produsage and producers did not specifically address individuals and activities in the GI community. That said, Budhathoki et al. (2008) came up independently with the term “produser” in a geographical context in their paper dealing with the changing role and influence of users in a spatial data infrastructure. Along the same vein, Turner (2006 & 2007) suggested the term “neogeography” to encompass “geographical techniques and tools used for personal activities or for utilization by a non-expert group of users; not formal or analytical”. Goodchild (2007) coined the term “Volunteered Geographic Information” (or VGI) to define the user-generated geospatial content being created in these and many other sites to satisfy a variety of needs within industry, government, and social networking communities.

VGI to date in most applications has taken the form of georeferenced point- and line-based data along with (usually) a limited set of textual and sometimes image or video attributes. Contributions of area-based features have also been made,

but the proportion would be relatively small in relation to the other data types. While important if in the form of additional descriptors or updates, the amount of attribute data accompanying the contributions is usually limited to a few entries, tags, or free-form comments. The organization of such tags would typically not conform to any standards-based metadata specifications endorsed by public or private mapping organizations, although organizations like OpenStreetMap are well on their way to defining more extensive sets of structuring and tagging specifications.

As large private companies have already discovered, the potential exists for government mapping agencies to harness the power of Web 2.0, new media and voluntarism in order to improve their own change detection and geospatial data updating processes. Budgets for such government digital map maintenance activities in some jurisdictions are either declining or non-existent. VGI updates may represent a real opportunity for such institutions to keep databases in "high-use" areas up to date and to even enrich or supplement the attributes of selected features.

In a broader sense, such voluntarism can ultimately change the balance between traditional values, practices and rules (Georgiadou, 2008). At the very least, it has the power to complement existing practices and enable new production systems. However, focusing purely on the "information" aspects of VGI ignores the rich human element driving this phenomenon. As Bruns (2008) argues, external organizations and produsage communities alike must strive to better understand the processes by which they operate -- and by which they generate content.

Important questions remain over people's motivation to volunteer information and the processes ultimately required to take into account not only issues of quality of the geographic information provided, but also the values and rationalities of the volunteer contributors and the performance of the new social production system. The question: "What motivates people to voluntarily contribute information?" has already formed the basis for empirical research into characterizing both contributors *and their contributions* to open source software development [e.g., (Raymond, 1990); (Benkler, 2002); and (Krishnamurthy, 2002)] and to Wikipedia [e.g., (Anthony et al, 2005); (Kittur et al., 2007); (Ortega et al., 2007) and many others].

Can we assume that VGI contributors will follow documented trends similar to those of voluntary contributors and contributions found in the Open Source software and Wikipedia communities – especially when those contributions may ultimately be to more "formal" or authoritative data sources? Are there important differences within and among VGI contributors that may influence their behavior and, ultimately, the nature, frequency and quality of their contributions? Large

public and private mapping institutions should be interested in finding answers to such questions.

To date, only a limited number of research findings addressing these particular questions in a VGI-specific context have appeared in print. However, early lessons and analogies may be drawn from broader GIS and spatial data infrastructure research and crowdsourcing/VGI-specific work now underway in key centres in (especially) North America and Europe [e.g., (Harvey, 2003); (Kuhn, 2007); (Bishr and Kuhn, 2007); (Craglia et al., 2008); (Budhathoki et al., 2008); (Elwood, 2008 and 2008a), (Mummidi and Krumm, 2008) and others]. An examination of research findings in Spatial Data Infrastructure (SDI) and Public Participation GIS (PPGIS) provides a basis for understanding relationships between interested citizens and government authorities at different levels [e.g., (Craig et al., 2002), (Haklay & Harrison, 2002); (Sieber, 2006); (Crutcher and Zook, 2009) and others]. Finally, more sophisticated Web 2.0-based tools are emerging to enhance the mapping abilities of users in this regard [(Hudson-Smith et al, 2009) and others.]

If VGI does represent a potential opportunity for large mapping organizations with respect to the authoritative databases they manage, how are they to evaluate the advantages and risks involved? Important questions remain to be answered. For example:

- (1) *Are we sure people will want to contribute to government in the same way they contribute to social networks and even to industry?*

The Economist (2008a) points out that "It is noticeable how individuals may be less concerned about giving away personal information to a private company than to a government organization". Citizen to Citizen (or "C2C") literature suggests that citizens interact with other citizens to promote the common good, but avoid direct relation to the government (IAB, 2008).

- (2) *What questions should an organization ask in determining how, if at all, it should employ VGI provided by producers?*

What problem(s) is the organization trying to address by incorporating such information? What are the benefits and risks? What criteria determine whether or not such an initiative is considered effective by its stakeholders? Given these criteria, how does such an initiative need to be resourced in terms of people and technology in order to be effective? Are there any institutional and/or cultural constraints that must be addressed?

- (3) *How does an organization assess the credibility of a new producer and the degree of trust it can place in that person's contributions?*

How is credibility assessed and/or conferred, and who does the ongoing evaluation of contributions? Members of the mapping organization? A

moderated on-line community? Members of the Web at large? What is most effective in terms of delivering the most credible input with the fastest turnaround times?

- (4) *How do organizations attract new volunteer producers? How do they keep existing volunteers "engaged" -- or is it assumed they will cycle in and out?*

Such questions are critical given that completeness and timeliness of a given geospatial dataset can be important public policy drivers to a national mapping organization. Longitudinal studies of members of social networks, wiki communities and even on-line auction sites are required to determine what proportion of individuals "stick" with a given community over a long period versus how many leave after a few transactions.

These questions form the basis for a larger program of research now underway by the senior author's group at the University of New Brunswick. In this paper, the authors describe the challenges involved in describing and classifying both the motivations of people who volunteer geospatial information and the nature of their contributions. After reviewing related research that treats the questions of voluntary contributors and their contributions in other fields, the authors offer different taxonomies that can help researchers clarify what is at stake with respect to geospatial information contributors. They identify early lessons which may be drawn from this research, and suggest questions which may be posed by large mapping organizations when considering the potential opportunities and risks associated with encouraging and employing Volunteered Geographic Information in their programs.

## **2. THE CONTRIBUTORS AND THEIR MOTIVATIONS**

### **2.1 Characterizing the Contributors: Early Efforts**

Influential enthusiasts like those mentioned above as well as O'Reilly (2005), Tapscott & Williams (2007), Cook (2008) and Shirky (2008) see tremendous benefit from this "revolution" in user contributions. However, critics like Robert McHenry (2004), Jaron Lanai (2006) and Andrew Keen (2007) are equally articulate in their concerns that "crowdsourcing" represents a disturbing trend that increases the influence of amateurs at the expense of legitimate experts and professional media organizations.

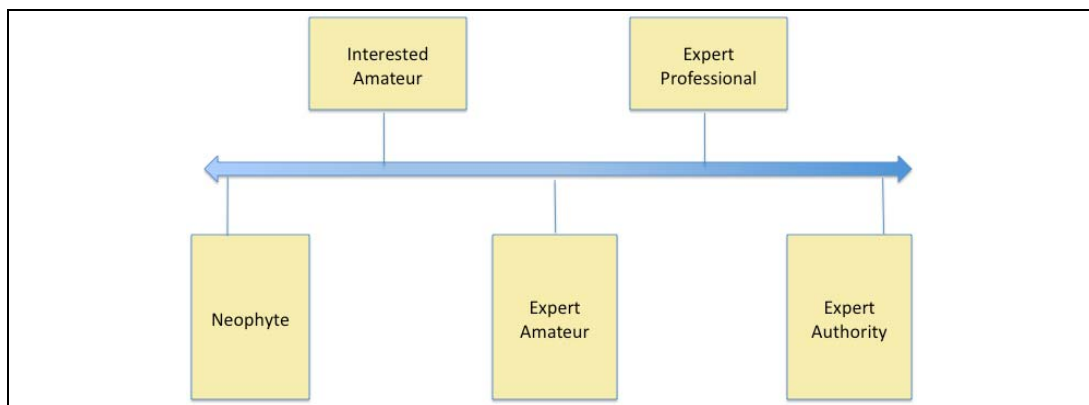
In what has become a very polarized debate, summarizing this literature suggests that such contributors may simplistically be broken down into five overlapping categories along a spectrum (Figure 2):

- (1) *"Neophyte"* -- someone with no formal background in a subject, but possessing the interest, time, and willingness to offer an opinion on a subject;

- (2) *"Interested Amateur"* -- someone who has "discovered" their interest in a subject, begun reading the background literature, consulted with other colleagues and experts about specific issues, is experimenting with its application, and is gaining experience in appreciating the subject;
- (3) *"Expert Amateur"* -- someone who may know a great deal about a subject, practices it passionately on occasion, but still does not rely on it for a living;
- (4) *"Expert Professional"* -- someone who has studied & practices a subject, relies on that knowledge for a living, and may be sued if their products, opinions and/or recommendations are proven inadequate, incorrect or libelous; and
- (5) *"Expert Authority"* -- someone who has widely studied and long practiced a subject to the point where he or she is recognized to possess an established record of providing high-quality products and services and/or well-informed opinions -- and stands to lose that reputation and perhaps their livelihood if that credibility is lost even temporarily.

Given the imperfect ways humans assess information, clearly the power of guilds & professional associations, peer groups, cliques and social networks still determines who is "in" and who is "out" of each group. For example, the *first* inclination of a mapping organization might be to assess a higher level of credibility or "trust" to contributions from another surveying or mapping organization or professional individual. However, as will be seen below, this taken in isolation is too simplistic a criterion and should only be only one consideration of many.

**Figure 2: The Spectrum of Contributors: A Simplistic View**



In analyzing the discourse of the two opposing camps debating the value of user-generated contributions, both sides defend their respective positions by selectively targeting of groups along the spectrum and characterizing them in

terms of their perceived competence and legal accountability. Favorable articles by Tapscott, O'Reilly and others tend to characterize the average contributor as usually being either an "Expert Amateur" or, at worst, a capable "Interested Amateur", and tend to ignore issues of legal accountability. In contrast, the more critical articles by McHenry, Keen and others offer anecdotes showing the consequences of accepting data from either incompetent "Neophytes" or misinformed "Interested Amateurs". They also emphasize, rightly, that professionals and commercial media sources could be sued for providing incorrect, deliberately misleading or libelous information. Given the acceptance of anonymity in offering opinions and the reluctance of Internet Service Providers to give details of site owners or contributors, it has been to date very problematic to take legal action against individual amateur contributors.

While useful in its provocation, VGI contributors cannot be easily characterized using the simple spectrum suggested in Figure 2. The issue is more multi-dimensional in nature and belies the easy acceptance or rejection of a given contributor. For example, using this spectrum, an "Expert Professional" may understand an organization's mapping specifications and the limitations of a given GPS unit, but her knowledge of the attributes or history of a given geographic feature may be limited. A "Neophyte" contributor may know little to nothing about positioning technologies or procedures but be very familiar with features in the location being mapped. In still another situation, an "Interested Amateur" may have a solid understanding of how to use a handheld GPS receiver and related Web mapping software, but have no knowledge of the formal specifications associated with locating, delineating and classifying such features in an authoritative database.

Clearly, then, the labels of "professional" and "amateur" are in themselves less than satisfactory descriptors when it comes to characterizing VGI contributors. More extensive research is required in order to more formally define the requirements, capabilities, risks and safeguards with respect to VGI contributions. In this regard, Goodchild (2009) begins a balanced and critical discussion of this in his examination of the nature of "geographic expertise". Recognizing that "... the old distinction between the non-expert amateur and the expert professional is quickly blurring", he describes through examples a growing willingness of amateurs to be involved in the mapping process, a need for new models for defining the people involved, and a growing recognition that "...we are all experts in our own local communities".

Still, there remains considerable value in investigating the opportunities, risks and necessary processes & safeguards associated with involving a wider group of contributors in maintaining, updating and upgrading authoritative databases over time. With appropriate processes in place, VGI represents an excellent



opportunity to at least improve the change detection process and, in future, create more up-to-date databases with richer labelling and attributes.

At least four different but overlapping contexts exist today in which individuals voluntarily contribute spatial information in support of a given purpose:

- (1) "*Mapping and Navigation*" – where the goal may be a contribution to a public map series (e.g., the USGS National Map Corps) or a database supporting a navigation or routing service (e.g., TomTom, Tele Atlas, NAVTEQ, etc.).
- (2) "*Social Networks*" – where the contribution may be made to a site like (e.g.,) the Christmas Bird Count, Open Street Map, Platial.com, Wayfaring.com, etc.
- (3) "*Civic/Governmental*" – where the contribution supports some act as a concerned citizen of a given town or city (e.g., PPGIS input), or a member of an environmental or animal rights group.
- (4) "*Emergency Reporting*" – where the contribution supports the reporting of the presence and extent of major accidents, incidents, and natural or man-made disasters (wildfires, flooding, protests, etc.)

Table 1 provides examples of individuals who might fall into each category in these four different contexts. Discussions of where "context" may play a role in examining and leveraging contributor motivations are included in Section 4 of this paper.

Less charged approaches to characterizing contributors may be drawn from empirical investigations by researchers interested in classifying volunteer contributions to Wikipedia and Free or Open-Source Software (or "F/OSS") communities. For example, the number and type of persons who ultimately contribute to Wikipedia has been the subject of rigorous investigation. One of Wikipedia's founders suggested "2% of the users do 75% of the work" (Wales, 2005). Subsequent in-depth analyses of Wikipedia contributions by Kittur et al. (2007), Ortega et al. (2007), Priedhorsky et al. (2007) and others confirm that even smaller percentages of committed, registered contributors -- called "zealots" by Anthony et al. (2005), "insiders" by Swartz (2006), and "elite users" by others - undertake the vast majority of the individual edits. However, they also found that a significant proportion of *new content contributions* comes from *occasional* contributors or, in the words of Anthony et al., "good Samaritans".

**Table 1: Examples of VGI Contributors in Each Category along the Spectrum**

	<b>Mapping and Navigation</b> (Example: GPS-based Car Navigation)	<b>Social Networks</b> (Example: OpenStreetMap)	<b>Civic/ Governmental</b> (Example: PPGIS)	<b>Emergency Reporting</b> (Example: Disaster Reporting)
<b>Neophyte</b>	Relies on unit to provide directions and follows instructions to add basic point information using the Unit.	Identified gaps in map coverage, familiar with the locale, and has obtained the requisite GPS equipment. Interested in making a first contribution.	Views a GIS map in a town hall meeting around the siting of a power plant in the town	May use cellphone to add basic information detailing location of a potential new wildfire outbreak.
<b>Interested Amateur</b>	Owns a personal system, uses it extensively, has made several contributions. Is aware of both technology strengths & limitations and procedures required to make reliable contributions.	Owns the equipment; familiar with data editing software & processes. Regular contributor of edited map data and may assess other contributions.	Citizen fashions a map to present a counter claim in a town hall meeting around the siting of a power plant in the town	May drive from place to place shooting geotagged photos showing extent of floodwaters
<b>Expert Amateur</b>	Familiar with the strengths and weaknesses of multiple systems, has owned more than one. May assess and occasionally amend the contributions of others.	Expert with the requisite equipment. Regularly assesses & edits contributions from others. Participates in specification development & decision-making.	Individual familiar with conditions in a given neighborhood and with the operation of the Web-based PPGIS system in use.	Familiar with requirements for data useful to emergency response personnel and may voluntarily travel to sites to provide such information on an "on-call" basis.

<b>Expert Professional</b>	Mapping or Location-Based Services professional.	Mapping or Location-Based Services professional.	Practicing Urban Planner	Emergency planning and/or response personnel tasked with mapping the position and geographic extent of a given flood or wildfire.
<b>Expert Authority</b>	Specialist consulted by other professionals re: specific problems and/or new developments.		City Planner with extensive knowledge of developments in the area of interest.	Specialist consulted by other professionals re: specific problems and/or new developments.

Research by Anthony et al., Swartz, Ortega et al., Priedhorsky et al. (2007) and others have further characterized contributors by:

- their *humanity* (i.e., whether or not edit operations are made by a human or by a recognized automated “bot” routine);
- the *frequency, type and degree* of a contributor’s edit operations;
- the *quality and veracity* of a contributor’s operations (in terms of whether or not a given edit is subsequently changed by someone else); and even
- whether or not an individual’s *reputation for reliability* in terms of past contributions and edits influences the “lifespan” of subsequent contributions.

There are reasons to differentiate between frequency, type and degree of a contribution. For example, the "Good Samaritan" content providers mentioned by Anthony et al. (2005) may actually make very few unique contributions, but they are important in terms of new content. On the other hand, the "elite regulars" mentioned in the same article provide frequent minor contributions that improve the compliance of the content with the norms and specifications of the overall database.

Parallels with volunteered geographic information may be found in the latter three characterizations. For example, two major road network providers claim that many of their individual contributors may be satisfied to make only one or two

contributions – often concerning new roads or updates in their own immediate neighbourhood (Coleman et al, 2009). Further, an early analysis of OpenStreetMap contributors suggests that a very small number of individuals contribute the majority of content to that database (O'Donovan, 2008).

## 2.2 Examining Motivations to Contribute

To better understand *why* individuals contribute geographic information, lessons may again be drawn from experiences in the Wikipedia and F/OSS communities. Empirical research by Anthony et al. (2005), Kuznetsov (2006) and Schroer & Hertel (2007) all build from a social-movement research base to interpret why people contribute to Wikipedia. Seminal work by Benkler (2002), as well as research by Lakhani and Wolf (2005) among others, suggests that F/OSS developers are encouraged by slightly different motivators than those reported by Wikipedia contributors. Finally, armed with consumer marketplace examples, Cook (2008) offers reasons as to why people actively provide information to on-line User Contribution Systems of all kinds.

Consolidating and summarizing these lists of F/OSS, Wikipedia and UCS motivators yields the following list of motivators to make constructive contributions:

- (1) *Altruism* – contributing purely for the benefit of others with no promise of gain or improvement of one's own personal situation;
- (2) *Professional or Personal Interest* – making a contribution as part of an existing job, mandate or personal project;
- (3) *Intellectual Stimulation* -- improvement of technical skills, knowledge and experience gained through contributions;
- (4) *Protection or enhancement of a personal investment* – where offering a practical solution to a shared problem offers an immediate payback for participation through shared improvement of a common resource;
- (5) *Social Reward* -- by being part of a larger network or virtual community where -- through collaboration, discussion and development of the resource – contributors acquire "...a sense of common purpose and belonging that unites them into one community" and encourages further sharing (Kuznetsov, 2006);
- (6) *Enhanced Personal Reputation* -- providing the opportunity for registered contributors to develop on-line identities that are respected, trusted and valued by their Wikipedian peers, thereby increasing their own sense of self-worth;
- (7) Provides an *Outlet for creative & independent self-expression*; and

- (8) *Pride of Place* – where adding information about one's own group or community may be good for public relations, tourism, economic development, or simply demonstrating that one's own street or establishment is "on the map".

One can see examples of how many of these motivators apply within VGI applications. *Pride of Place* certainly plays a major role in encouraging individuals to make updates to road centreline and point-of-interest data in Google Earth, OpenStreetMap and Tele Atlas or NAVTEQ datasets covering their home town. *Altruism, Professional or Personal Interest*, and possibly *Social Reward* are all strong motivators for those citizens engaged in reporting specific instances or extents of natural or man-made disasters [(Laituri and Kodrich, 2008), (Pultar et al., 2008); (Crutcher and Zook, 2009)]. Similarly, *Social Reward, Professional or Personal Interest, Pride of Place*, and possibly *Intellectual Stimulation* may all be justifiable motivators for those individuals participating in and contributing to OpenStreetMap "mapping parties". *Protection or Enhancement of a Personal Investment* motivates individuals to use TomTom's MapShare™ service to update data on their TomTom personal navigation unit. Contributing as an *Outlet for creative and independent self-expression* does not seem to be a motivator for VGI contributions per se, though an increasing amount of "GPS Art" is now being shared via the Web<sup>1</sup>.

There are more negative but no less important motivators to consider as well. Not all contributors may be interested in providing objective or reliable information. The motivations behind some such contributors are easy to identify:

- (1) *Mischief*: Mischievous persons or "vandals" hoping to generate skepticism or confusion by replacing legitimate entries with nonsensical or overtly offensive content. Viegas et al. (2004) and more recently Friedhorsky et al. (2007) offer excellent examples of empirical research into quantifying and characterizing the prevalence of such entries in Wikipedia and propose approaches to their quick correction.
- (2) *Agenda*: Independent individuals or representatives motivated by beliefs in a given community, organization or cause – By tracing individual Wikipedia contributions back to specific network IP addresses, the recently-developed WikiScanner software identified and characterized the practices of specific corporations, government institutions, and special interest groups in systematically making overtly biased, incorrect and/or misleading modifications to Wikipedia entries of direct interest to them, their members and/or their agenda (Borland, 2007).

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<sup>1</sup> See examples of GPS Art on the Web at <http://www.gpsdrawing.com/gallery.html>. (Last accessed 7 October 2009.)

(3) *Malice and/or Criminal Intent*: Individuals possessing malicious (and possibly criminal) intent in hopes of personal gain – A recent example of this occurred when unknown perpetrators posted false report to the *iReport.com* site re: Steve Jobs hospitalization, resulting in them causing and benefiting from a short-term price fluctuation in Apple shares (Cohen, 2008a).

As one progresses from (1) to (3), it is more difficult to develop automated approaches to monitoring, identification, editing and overall QA. While far from tamper-proof, there *are* tools now being developed that can at least ostensibly help identify the location of the computer from which a contribution is being made. For example, *WikiScanner* (also known as Wikipedia Scanner) is a tool created in August 2007 by Caltech graduate student Virgil Griffith (Borland, 2007). It consists of a publicly searchable database that links millions of anonymous Wikipedia edits to the organizations where those edits apparently originated, by cross-referencing the edits with data on the owners of the associated block of IP addresses. In turn, the corresponding geographic location(s) associated with those respective IP addresses may also be mapped.

The original version was not foolproof. WikiScanner does not work on edits made by an editor who is logged-in under a username. In that case, the data shows only the username and not the IP address. WikiScanner also cannot distinguish edits made by authorized users of an organization's computers from edits made by unauthorized intruders, or by users of public-access computers that may be part of an organization's network. New developments now underway by a larger team will make WikiScanner 2.0, now a component of a larger WikiWatcher suite of tools, even more powerful (WikiWatcher, 2009).

Even with such tools, vigilance is essential. In public planning instances, for example, planning professionals *should* be aware of and be prepared to deal with the "...digital vandalism, yelling, and deliberate misdirection" coming from some contributors and that developing a "healthy skepticism" of data coming from VGI sources may in fact help target staff investigations and avoid the spread of false rumours during a plan development process (Tulloch, 2008).

### **3. CHARACTERIZING THE CONTRIBUTIONS**

Examining the contributors and their motivations is only part of the investigations underway. Organizations examining the potential of VGI must be interested in both the credibility of the contributors and the reliability of their contributions (Flanagin and Metzger, 2008) – and be able to understand the difference between the two concepts. Even the most credible of contributors on occasion may make an erroneous or otherwise unreliable contribution, so it is important to organize and classify the different types of potential contributions.

Drawing from the work of Viégas et al. (2004), Anthony et al. (2005), Swartz (2006) and especially Priedhorsky et al. (2007), contributions to Wikipedia may be termed either “Constructive” or “Damaging” and fall into one of ten categories. Specifically:

### **Constructive**

- Legitimate New Content – a new article or entry;
- Constructive amendments – clarifications and additions that improve the veracity, completeness and depth of the original entry;
- Validation & Repair – identifying damaging content and making the appropriate corrections

and

- Minor Edits & Format Changes.

### **Damaging**

- Mass Deletes – Removal of all or nearly all of an article’s content;
- Nonsense – Text that is meaningless to the reader and/or irrelevant to the context of the article;
- Spam – Advertisements or non-useful links incorporated into the article;
- Partial deletes -- Removal of some of an article’s content, from a few sentences to many paragraphs;
- Offensive content – Inclusion of (e.g.) obscenities, hate speech, unwarranted attacks on public figures, unexpected links to pornography;
- Misinformation – Clearly false information, such as changed dates, subtle insertions or removal of certain words which changes the meaning of a passage, stating incorrectly that a public figure is dead, etc.

There are corresponding geographical examples of all four types of Constructive Contributions. In terms of damaging contributions, the possibility of a Partial Delete to a map database could have serious consequences. While they may occur, the likelihood of not easily detecting and correcting Mass Deletes or Nonsense contributions (e.g. GPS Art) to a map database would be low. "Misinformation" may fall into two categories. *Unintentional* misinformation may be provided where someone genuinely believes they are providing reliable new information or updates but, due to procedural errors, innocent misinterpretations, or reliance on false second-hand information, incorrect information is provided. Contributions of deliberate or *intentional* misinformation are usually driven by a conscious agenda.

The latter types of damaging contributions are more difficult to identify, interpret, and track. In some cases, it may be arguable whether a particular amendment is indeed “constructive” or “damaging”. Coming back to individuals and organizations with an agenda, there are already examples of citizen groups and organizations which would like to see digital map and attribute data amended to, for example, re-route traffic around older village centers, residential neighborhoods and school zones [e.g., (Lyll, 2007); (Stichting Onderzoek Navigatiesystemen, 2007)]. Again, in such cases, WikiScanner-type tracking technologies may be useful in identifying logical linkages between the nature & location of contributors and their respective contributions.

#### **4. GEOSPATIAL PRODUSERS AND AUTHORITATIVE DATABASES**

##### **4.1 Lessons Learned**

What early lessons may be drawn from these findings, and how may they be applied by institutions interested in incorporating volunteered geographic information into their database maintenance processes?

First, as mentioned earlier, VGI need not necessarily be new graphical information. In many instances, it may be updated attributes (dirt road now paved) or even additional information (the official name and/or purpose of a given building). Most of the data submitted by TomTom *MapShare™* customers is updated attribute information (Coleman, 2009), and one important function of the USGS National Map Corps still available gives contributors the ability to label buildings and points of interest (Bearden, 2007). This is an important consideration to institutional skeptics who may question the reliability of graphical updates provided by "inexperienced" volunteers.

Second, volunteer contributors clearly desire some recognition of their contribution. Such recognition may range from early acknowledgement of a contribution via an automatic return e-mail message (a practice adopted by NAVTEQ's MapReporter site, for example) to more formal recognition on a website's "List of Contributors" or even in metadata.

Third, contributors want to see their contribution used -- and quickly. Case studies cited from both the Wikipedia and the Open Source Software communities identified the importance of contributions being acted upon and either incorporated or refuted quickly. Bearden (2007) pointed out volunteer discouragement when the US Geological Survey was unable to quickly incorporate map updates by USGS National Map Corps members.

The fourth lesson learned is that there are ways to assess contributor credibility and by extension, validate the corresponding contributions. There are definite



spatial considerations that make VGI contributions unique, and these may be used to support or refute the credibility of a given contributor [(Flanagin and Metzger, 2007); (Bishr and Kuhn, 2007); (Bishr and Mantelas, 2008); (Coleman et al., 2009)]. For example, while anyone from anywhere may be in a position to contribute to an article on "Mozart" or "Orienteering", a volunteered contribution of mapped information covering a brand new subdivision in Ottawa, Canada may be justifiably questioned if the contribution is found -- through WikiScanner or an equivalent technology -- to originate from a network IP address based in the Netherlands. (Note: Geographical knowledge may be "locus-related" as well. Long-haul truck drivers may be good sources of information concerning data within a certain buffer along a given route -- say from Amsterdam to Paris or Boston to Washington, D.C. Indeed, such people are valued sources of updates to value-added road network data suppliers like TomTom, Tele Atlas, NAVTEQ, and others.)

Similarly, the date and time at which a volunteered contribution is made concerning (for example) a given segment of highway may have a bearing on its credibility --- especially when trying to assess the reliability of two or more competing or contradictory contributions. Bishr and Kuhn (2007) offer a more in-depth look at spatio-temporal considerations which may be taken into account when assessing the credibility of a given contributor. Use of "WikiScanner-like" tools and other methods to assess the relative credibility of different contributors and the reliability of their contributions will be the subject of future research by the authors.

Finally, as pointed out by both Shirky (2008) and Bruns (2008), in an environment where many people have access to inexpensive means of "production" -- be it a keyboard, cellphone camera, digital camcorder, or GPS in a PDA -- the emphasis of both consumers and professionals understandably shifts away from production and towards *filtering*. Depending on the type of information being collected, there may in future even be a mix of responsibilities when it comes to determining who actually performs such filtering or quality control -- trained professionals or a network of informed consumers. In densely-populated areas with a high number of potential volunteer contributors, the ability of someone's contribution to withstand the scrutiny of several or many other knowledgeable contributors/reviewers may be the ultimate test of its validity.

#### **4.2 Does Context Matter?**

The issue of context was raised earlier. Does it matter? Is there a difference in the type or motivation of individuals offering VGI in the context of emergency reporting, in social networks or in PPGIS versus those offering such information to mapping and navigation organizations?

Not in terms of motivation. Based on information gleaned from mapping/navigation data firms like TomTom and NAVTEQ (Coleman, 2009), the OpenStreetMap initiative, and the documented experience of the USGS National Map Corps (Bearden, 2007), such key motivators as *Professional or Personal Interest*, *Intellectual Stimulation*, *Enhanced Personal Reputation*, and *Pride of Place* all may apply depending on the individual. While *Social Reward* may seem less of a motivator in this context, the experience of the OpenStreetMap initiative, Google's work in engaging volunteers to map in emerging nations, and USGS National Map Corps organizations all suggest a strong affiliation of the volunteers with the common cause at hand.

There *may* be a difference in terms of number or extent of such contributions when compared with other contexts. *Pride of Place* as a motivator, for example, only goes so far. A single volunteer may be willing to contribute new information about his or her immediate area, but most would be reluctant to engage in such work for an extended period over a larger area. A longitudinal study of individual participation in building OpenStreetMap coverage over a given region would provide valuable insights in this regard. Further, while the requirement for a limited amount of tagging of the mapped data is understood, it is questionable whether or not volunteers would have the patience to adhere to the more extensive feature classification and metadata requirements of public mapping programs.

Cultural theory literature suggests that what *does* matter is that different motivations derive from alternative ways humans have of perceiving reality. Fortunately, these ways are limited in number and comprise *individualism*, *hierarchism*, and *egalitarianism* [(Thompson et al, 1990) and (Thompson et al, 1999)]. Each of the ways of perceiving reality structures social relationships differently and features different beliefs about human nature, different values and motivations.

Relating this to the motivators described earlier in this paper, *individualists* believe that other humans are self-seeking & profit-maximizing; they value efficiency and independence and are likely to be motivated by intellectual stimulation and the protection of personal investments. *Hierarchists* believe that other humans are malleable (i.e., "born in sin", but redeemable by firm and nurturing institutions), they value reliability and resilience and are motivated by professionalism. Finally, *egalitarians* view other humans as caring and cooperative, they value mutuality and reciprocity, and are motivated by social rewards and altruism.

Human actors' beliefs, their values and motivations shape their preferred governance styles. Cultural theory has shown empirically that 'clumsy' but viable governance arrangements among individualist, hierarchist and egalitarian actors

can emerge when all voices are included in the struggle and the contestation is harnessed to constructive, if noisy, argumentation (Verweij and Thompson, 2006).

### 4.3 Institutional Considerations

With all this in mind, public and private mapping organizations have some fundamental questions to ask themselves when considering the opportunities and risks posed by introducing and employing VGI in their production processes. For example:

- (1) *What is the rationale for VGI in this context? What problem or objective is being addressed here?* Considering VGI just because the potential exists will result in inconclusive pilot projects at best. If the organization has clear requirements in terms of faster updating cycles, a requirement to gather additional attribute information, reduced funds available for in-house production, or a strong need to involve the user community for other reasons, then alternative approaches involving VGI may be objectively assessed and compared in terms of characteristics, strengths and weaknesses.
- (2) *To what extent, if at all, should VGI be adopted?* To address the problem or objectives defined above, is it necessary to solicit and incorporate VGI updates directly into a database or use it only as a more user-driven means of change detection?
- (3) *How may credible VGI contributors be distinguished from those who may be incompetent, mischief-makers, or outright vandals?* Developing a better appreciation of potential contributors and their motivations is a start. Again, research underway by Bishr and Mantelas (2007), Budathoki et al. (2008), (Elwood, 2008a), Flanagan and Metzger (2008), Mummidi and Krumm (2008) and Coleman et al (2009) all speak to this, and technology tools mentioned earlier are available to help in this regard.
- (4) *How much control over content and quality are such organizations prepared to relinquish? Who makes the final decisions regarding the reliability of a given update?* These are not new questions. The same kinds of questions over control were posed 30-40 years ago when Canadian federal and provincial government departments began shifting from purely in-house mapping operations to a balance of in-house plus contract production by suppliers from the private-sector and from other government organizations. The focus of in-house expertise in many of these organizations was forced to shift from a pure production orientation to one of quality control and filtering. The same will be true here. The extent to which control is held by the

contributor, the institution, or "the crowd" of contributors assessing each other's contributions will be different in each organization.

- (5) *Will individuals remain interested in making contributions? Should an organization try to sustain a contributor's interest or assume most substantive content contributions will be made by "one-time-only" contributors?* The response to this question will drive the look and feel of the "front-end" of the contribution channels put in place. Assuming a small number of "elite contributors" or power users suggests a more sophisticated interface to a complex and multifunctional system. Satisfying a large number of "one-time-only" contributors will require a much simpler interface and more extensive post-processing behind the scenes.

If national mapping organizations wish to tap into the distributed knowledge, time and energy of volunteer "producers" to contribute authoritative geospatial data, they must be prepared to entertain some important procedural and cultural changes that build on the motivations and recognize the characteristics of the culture as articulated below (Bruns, 2008):

- (1) *Accept and respect rules imposed by the produsage community, much like commercial operators having to survive in the open source community.*

For example, geospatial producers would want to see their contributions acknowledged instantaneously, posted quickly, and ideally credited to them via tags or metadata entries. In order to keep their interest, the turnaround time from contribution to posting would have to be very short.

- (2) *Tolerate a regime of "heterarchy" instead of hierarchy, where the produsage community's values take precedence over traditional practices and policies.*

Releasing some control to "the crowd" over decisions whether or not to post a contribution would certainly represent a major shift to an organization used to very different kinds of quality assurance processes.

- (3) *Accept the fact that the geo-information "produced" is a perpetually unfinished artefact (or a "palimpsest", as Bruns terms it).*

The notion of authoritative geo-information in a state of constant imperfection and fluidity may be perceived by some to undermine government legitimacy. It maybe the most difficult barrier for government participation in produsage communities.

- (4) *Introduce new rules and/or legislation to account for and balance the rights of individual contributors to those of both the produsage community and the mapping organization.*

Here is where larger organizations have the opportunity to be proactive in a time of uncertainty and suggest new rules of their own which represent

positive compromises on both side. For example, even some of the most recognized evangelists of the "wiki" movement suggest some evolution of roles and responsibilities is required moving forward (Cohen, 2008b).

Finally, the cultural and process changes involved in shifting the planning and production focus from a "coverage-based" to a "feature-based" orientation cannot be underestimated. Road network firms like TomTom, NAVTEQ, and TelAtlas have already made this shift and realized quicker turnaround times of updates and improved customer service (TomTom, 2008), but many government topographic mapping organizations have not. How three such organizations have dealt with such change is the subject of a forthcoming paper (Coleman et al., 2009).

## 5. CONCLUDING REMARKS

In this paper, the authors have drawn from other related fields to characterize the motivations of volunteer contributors (or producers), and the different types of contributions they may make. They then extend these generic classifications to demonstrate how they may relate to contributions of geospatial information.

Going forward, if a mapping organization wishes to capitalize on a distributed network of volunteer geospatial data producers, then it must start refocusing attention across what happens both inside that organization *and also* in the new social network of geo-information production. New rules and standards will be required to take into account the values of these volunteers — equity, security, community building, privacy — in evaluating the performance of this new production system.

Depending on the type of information being collected, there may in future even be a mix of responsibilities when it comes to determining who actually performs such filtering or quality control — trained professionals or a network of informed consumers. Much will depend upon program design and acceptance criteria and, if the variety of examples already on the Web is any indication, the situation will likely be different from organization to organization.

Subsequent research will focus, first, on understanding analytically how geoinformation is produced and, second, on explaining the different forms that the governance of produsage *can* take (explanatory) and *should* take (normative) in empirical cases involving private, not-for-profit and public sector producers around the world. The cultural theory lens also holds promise for effective comparative empirical research on the governance of produsage around the world, and its applicability will be investigated over the coming months.

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## REFERENCES

- Anthony, D; Smith, S. and T. Williamson (2005). "Explaining quality in Internet collective goods: Zealots and good samaritans in the case of Wikipedia". Retrieved from <http://web.mit.edu/iandeseminar/Papers/Fall2005/anthony.pdf>.
- Bearden, M.J. (2007a) "The National Map Corps". Paper presented at Workshop on Volunteered Geographic Information, University of California at Santa Barbara, Dec 13-14. Available at [http://www.ncgia.ucsb.edu/projects/vgi/docs/position/Bearden\\_paper.pdf](http://www.ncgia.ucsb.edu/projects/vgi/docs/position/Bearden_paper.pdf). (Last accessed 10 February 2009)
- Benkler, Y. (2002). "Coase's Penguin, or, Linux and the Nature of the Firm". *Yale Law Journal*, Vol. 112, No. 3, pp. 367-445.
- Biersdorfer, J.D. (2007). "Updating Maps on the Spot and Sharing the Fixes". *New York Times* article, 14 June. Retrieved from <http://www.nytimes.com/2007/06/14/technology/14gps.html>.
- Bishr, M. and W. Kuhn (2007). "Geospatial information bottom- up: A matter of trust and semantics". In S. Fabrikant & M. Wachowicz (Eds.), *The European information society: Leading the way with geo-information* (pp. 365–387). Berlin: Springer
- Bishr, M., Mantelas L. (2008). "A trust and reputation model for filtering and classifying knowledge about urban growth." *GeoJournal*, (72), 229-237.
- Borland, J. (2007). "See Who's Editing Wikipedia - Diebold, the CIA, a Campaign". Politics/Online Rights Blog, *Wired*. Retrieved from [http://www.wired.com/politics/onlinerights/news/2007/08/wiki\\_tracker](http://www.wired.com/politics/onlinerights/news/2007/08/wiki_tracker)
- Bruns, A. (2006) "Towards produsage: Futures for user-led content production. Proceedings: Cultural Attitudes towards Communication and Technology, pp. 275-84, F. Sudweeks, H. Hrachovec, and C. Ess (eds). Murdoch University, Perth, Australia. Retrieved from [http://snurb.info/files/12132812018\\_towards\\_produsage\\_0.pdf](http://snurb.info/files/12132812018_towards_produsage_0.pdf)
- Bruns, A. (2008). *Blogs, Wikipedia, Second Life, and Beyond. From Production to Produsage*. New York: Peter Lang.

- Budhathoki, N.R., Bruce, B. and Z. Nedovic-Budic (2008). "Reconceptualizing the role of the user of spatial data infrastructure", *GeoJournal*, vol. 72, no. 3-4, pp. 149-160.
- Cohen, L. (2008a). "The rumor mill that won't stop running". Article in online edition of International Herald Tribune. 14 October. Retrieved from <http://www.ihb.com/articles/2008/10/14/business/rumors.php>.
- Cohen, L. (2008b). "Wikipedia May Restrict Public's Ability to Change Entries". *New York Times* on-line edition, 23 January.
- Coleman, D.J., Sabone, B. and N. Nkhwanana [2009]. "Volunteering Geographic Information to Authoritative Databases: Linking Contributor Motivations to Program Effectiveness". Submitted for review to *Geomatica* Special Issue on Volunteered Geographic Information. June.
- Cook, S. (2008). "Why Contributors Contribute" *Harvard Business Review*, October 2008. Retrieved from <http://usercontribution.intuit.com/The+Contribution+Revolution+linked+version+and>  
[http://harvardbusinessonline.hbsp.harvard.edu/b02/en/common/item\\_detail.jhtml;jsessionid=FVGEZXFEPDMRYAKRGWDR5VQBKE0YIISW?id=R0810C](http://harvardbusinessonline.hbsp.harvard.edu/b02/en/common/item_detail.jhtml;jsessionid=FVGEZXFEPDMRYAKRGWDR5VQBKE0YIISW?id=R0810C)
- Craglia, M. and Goodchild, M.F., and Annoni, A. and Camera, G. and Gould, M. and Kuhn, W. and Mark, D. and Masser, I. and Maguire, D. and Liang, S. and Parsons, E. (2008). "Next-Generation Digital Earth: A position paper from the Vespucci Initiative for the Advancement of Geographic Information Science." *International Journal of Spatial Data Infrastructures Research*, Vol. 3, pp. 146-167.
- Craig, W., Harris, T., & Weiner, D. (Eds.). (2002). *Community participation and geographic information systems*. London: Taylor and Francis.
- Crutcher, M., Zook M. (2009). "Placemarks and waterlines: Racialized cyberscapes in post-Katrina Google Earth." *Geoforum*, (40), pp. 523-534.
- Cuff, D., Hansen, M. and J. King (2008): "Urban Sensing: Out of the Woods". *Communications of the ACM*, Volume 51, Number 3, pp. 24-33.
- Economist. (2008a). "Identity Parade". *The Economist* Special Report Technology and Government. 14th February. Retrieved from [http://www.economist.com/specialreports/displaystory.cfm?story\\_id=10638196](http://www.economist.com/specialreports/displaystory.cfm?story_id=10638196)
- Elwood, S. (2008). "Volunteered geographic information: future research directions motivated by critical, participatory, and feminist GIS". *GeoJournal*, vol. 72, no. 3-4, pp. 173-183.
- Elwood, S. (2008). "Grassroots groups as stakeholders in spatial data infrastructures: Challenges and opportunities for local data development and sharing". *International Journal of Geographic Information Science*, vol. 22, pp. 71-90.

- Flanagin, A.J. & Metzger, M.J. (2008), "The credibility of volunteered geographic information", *GeoJournal*, vol. 72, no. 3-4, pp. 137-148.
- Georgiadou, Y. (2008). "Using geo-information: from a *market* to a *polis* perspective". Inaugural speech as incoming Professor of Geo-information for Governance, International Institute for Geo-Information Science and Earth Observation, Enschede, The Netherlands. 17 December.
- Goodchild, M.F. (2007). "Citizens as voluntary sensors: spatial data infrastructure in the world of Web 2.0" *International Journal of Spatial Data Infrastructures Research* 2: 24–32. (437) Retrieved from <http://ijsdir.jrc.ec.europa.eu/index.php/ijsdir/article/view/28/22>
- Goodchild, M.F. (2009). 'NeoGeography and the nature of geographic expertise', *Journal of Location Based Services*, Vol. 3, No. 2, p. 82-96.
- Google (2009). "Countries editable in Google Map Maker" (as of January 2009). Retrieved from <http://www.google.com/mapmaker/mapfiles/s/launched.html>.
- Haklay, M. and C. Harrison (2002). "Public Participation GIS in the UK and the USA: A cross cultural analysis" Proceedings of the 98<sup>th</sup> Annual Meeting of the American Association of Geographers. Retrieved from <http://homepages.ge.ucl.ac.uk/~mhaklay/pdf/HaklayandHarrison-PPGIS-AAG2002.pdf>.
- Harvey, F. (2003). "Developing geographic information infrastructures for local government: the role of trust". *The Canadian Geographer*. Vol. 47, No. 1, pp. 28-36.
- Helft, M. (2007). "With Tools on Web, Amateurs Reshape Mapmaking" *New York Times*, Technology Section, 26 July.
- Hudson-Smith, A., Crooks, A., Gibin, M., Milton, R. and M. Batty (2009). "NeoGeography and Web 2.0: concepts, tools and applications". *Journal of Location Based Services*, Vol. 3, No. 2, June 2009, pp. 118–145.
- IAB (2008). "User Generated Content, Social Media, and Advertising — An Overview". Interactive Advertising Bureau Platform Status Report. April. Retrieved from [http://www.iab.net/media/file/2008\\_ugc\\_platform.pdf](http://www.iab.net/media/file/2008_ugc_platform.pdf)
- Jones, Michael (2007). "Our Geospatial Future". Podcast of presentation at 2007 Cambridge Conference, Cambridge, UK. 17 July. [http://www.cambridgeconference.com/2007\\_conference\\_information/Podcasts/p3\\_michael\\_jones.mp3](http://www.cambridgeconference.com/2007_conference_information/Podcasts/p3_michael_jones.mp3)
- Keen, Andrew (2007). *The Cult of the Amateur: How today's internet is killing our culture*. Doubleday, New York, NY, USA



- Kittur, A., Chi, E., Pendleton, A., Suh, B. & Mytkowicz, T. (2007). "Power of the few vs. wisdom of the crowd: Wikipedia and the rise of the bourgeoisie". *Proceedings of the 25th Annual ACM Conference on Human Factors in Computing Systems*, April-May 2007.
- Krishnamurthy, S. 2005, "Cave or community?: An empirical examination of 100 mature open source projects", *First Monday*, vol. 10, no. Special Issue 2.
- Kuhn, W. (2007). "Volunteered Geographic Information and GIScience". Position Paper. Retrieved from:  
[http://www.ncgia.ucsb.edu/projects/vgi/docs/position/Kuhn\\_paper.pdf](http://www.ncgia.ucsb.edu/projects/vgi/docs/position/Kuhn_paper.pdf)
- Kuznetsov, S. (2006). "Motivations of contributors to Wikipedia." *ACM SIGCAS Computers and Society*, Vol. 36, No. 2.
- Laituri, M. and K. Kodrich (2008). "On Line Disaster Response Community: People as Sensors of High Magnitude Disasters Using Internet GIS" *Sensors* **2008**, 8, pp. 3037-3055
- Lanier, J. (2006). "Digital Maoism: The Hazards of the New Online Collectivism", *The Edge* 183 Retrieved from [http://www.edge.org/3rd\\_culture/lanier06/lanier06\\_index.html](http://www.edge.org/3rd_culture/lanier06/lanier06_index.html).
- Lyall, S. (2007). "Rural Britain wants to take itself off the GPS Map." *International Herald Tribune*, Europe on-line edition. 3 December. Retrieved from <http://www.iht.com/articles/2007/12/03/europe/gps.php>.
- McHenry, Robert (2004). "The Faith-Based Encyclopaedia". Column in *Technology, Commerce and Society Daily*, 15 November. Retrieved from <http://www.tcsdaily.com/article.aspx?id=111504A> *Daily*.
- McLaren, R. (2009). "The Role of Urban Sensing in Managing Megacities". *Proceedings of the FIG Commission 3 Workshop: Spatial Information for Sustainable Management of Urban Areas*, Mainz, Germany. February.
- Mummidi, L.N. and J. Krumm, (2008). "Discovering points of interest from users' map annotations", *GeoJournal* 72 (3-4), pp. 215-227
- O'Donovan, B. (2008). "Visualizations : Plot of rank versus percentage of contributions". ManyEyes Website: Analysis of the people contributing to the OpenStreetmap data. Retrieved from  
<http://manyeyes.alphaworks.ibm.com/manyeyes/visualizations/plot-of-rank-versus-percentage-of-co>
- O'Reilly, T. (2005). "What Is Web 2.0: Design Patterns and Business Models for the Next Generation of Software". Blog by Tim O'Reilly retrieved from <http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html>

- OECD 2007. "Participative Web: User-Created Content: Web 2.0, wikis and social networking ". Report DSTI/ICCP/IE(2006)7/FINAL, Working Party on the Information Economy, Committee for Information, Computer and Communications Policy, Directorate for Science, Technology and Industry, Organisation for Economic Co-Operation And Development. 12 April. OECD Publishing. ISBN 9264037462, 9789264037465
- Ortega, F. and G. Barahona, J. M. (2007) "Quantitative Analysis of the Wikipedia Community of Users", *Proceedings of the WikiSym Conference*, pp. 75. ACM Press, New York, NY USA. Retrieved from <http://libresoft.es/downloads/wiki35f-ortega.pdf>
- Priedhorsky, R., Chen, J., Lam, S.K., Panciera, K., Terveen, L. & Reidl, J. (2007). "Creating, Destroying, and Restoring Value in Wikipedia", *Proceedings of the 2007 International ACM Conference on Supporting Group Work*, pp. 259. Sanibel Island, FL., Nov 4-7. Retrieved from <http://portal.acm.org.proxy.hil.unb.ca/citation.cfm?id=1316624.1316663>.
- Pultar, E., Raubal M., Cova T. J., Goodchild M. F. (2009). "Dynamic GIS Case Studies: Wildfire Evacuation and Volunteered Geographic Information." *Transactions in GIS*. Vol. 13, 85-104.
- Raymond, E.S. (1999). "The Cathedral and the Bazaar", *Knowledge, Technology, and Policy*, vol. 12, no. 3, pp. 23-49. September
- Shirky, C. (2008). *Here comes everybody: the power of organizing without organizations*. Penguin Group.
- Sieber, R. (2006). "Public participation geographic information systems: A literature review and framework". *Annals of the American Association of Geography*, 96(3), 491–507.
- Stichting Onderzoek Navigatiesystemen (2007). "Navigation Systems Seriously Undermine Road Safety: Software Errors Are Being Ignored" Research Report nav-001. The Hague, The Netherlands, Dec. 10. Retrieved from [http://www.stichtingonderzoeknavigatiesystemen.nl/\\_files/son\\_nav001\\_20071210\\_en\\_Navigation\\_systems\\_seriously\\_undermine\\_road\\_savety.pdf](http://www.stichtingonderzoeknavigatiesystemen.nl/_files/son_nav001_20071210_en_Navigation_systems_seriously_undermine_road_savety.pdf)
- Swartz, A. (2006) Who writes wikipedia? Retrieved from <http://www.aaronsw.com/weblog/whowriteswikipedia>. September.
- Tang, Teresa and J. Zhao and D. J. Coleman [2005]. "Design of a GIS-enabled Online Discussion Forum for Participatory Planning". *Proceedings of the 4<sup>th</sup> Annual Public Participation GIS Conference*, Cleveland State University, Cleveland, Ohio, USA. Urban and Regional Information Systems Association. August. (CD-ROM)
- Tapscott, D. and A.D. Williams (2007). *Wikinomics: How mass collaboration changes everything*. Penguin Group, New York, NY, USA.

- Thompson, M., R. Ellis and A. Wildavsky (1990) *Cultural Theory*. Boulder CO and Oxford, West View.
- Thompson, M., G. Grendstad and P. Selle (Eds) (1999) *Cultural Theory as Political Science*. London: Routledge.
- TomTom (2008). "TomTom Announces Five Millionth Map Share™ Improvement". TomTom News, 16 December.  
<http://www.tomtom.com/news/category.php?ID=4&NID=660&Lid=4> (Last accessed 1 May 2009)
- Tulloch, D.L. (2008). "Is VGI participation? From vernal pools to video games". *GeoJournal*, Vol. 72, pp. 161-171.
- Turner, Andrew (2006). *Introduction to Neogeography* (O'Reilly Short Cuts series). O'Reilly Media.
- Turner, Andrew (2007). *Neogeography - towards a definition*. A weblog posting, posted on *High Earth Orbit*, 6th December 2007. Retrieved from <http://highearthorbit.com/neogeography-towards-a-definition/>
- Verweij, M. and M. Thompson (eds) (2006) *Clumsy Solutions For A Complex World: Governance, Politics and Plural Perceptions*, Basingstoke: Palgrave.
- Viégas, FB, Wattenberg, M. and K. Dave (2004). "Studying cooperation and conflict between authors with history flow visualizations". In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 575–582, April.
- WikiWatcher (2009). WikiWatcher FAQ. Available at URL <http://virgil.gr/67>.